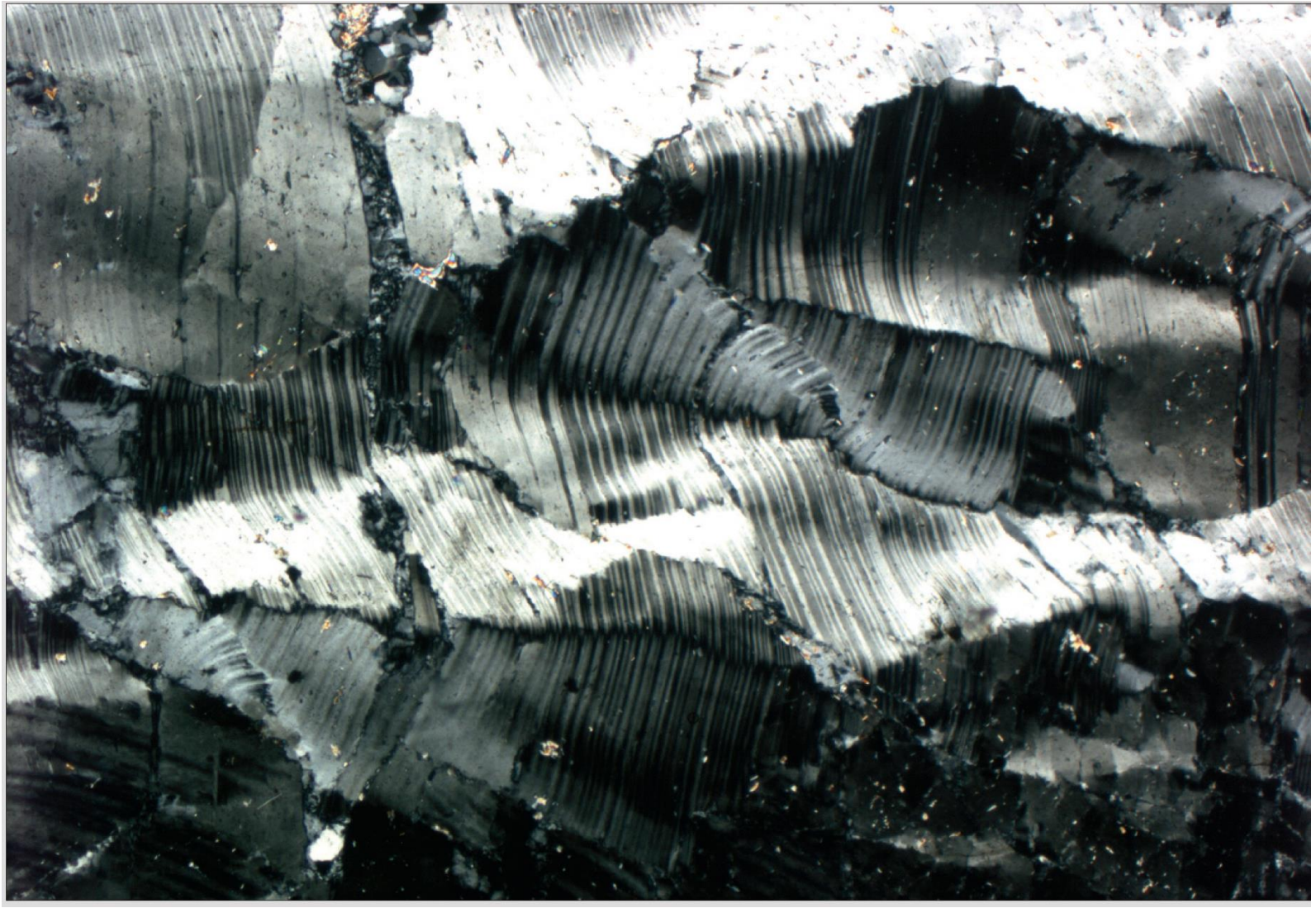
Lab 3

Foliations and microscopic deformation structures

(Most photos are from the book Microtectonics)

Mineral deformation behaviors



CPL

Kink and fold in a plagioclase porphyroclast

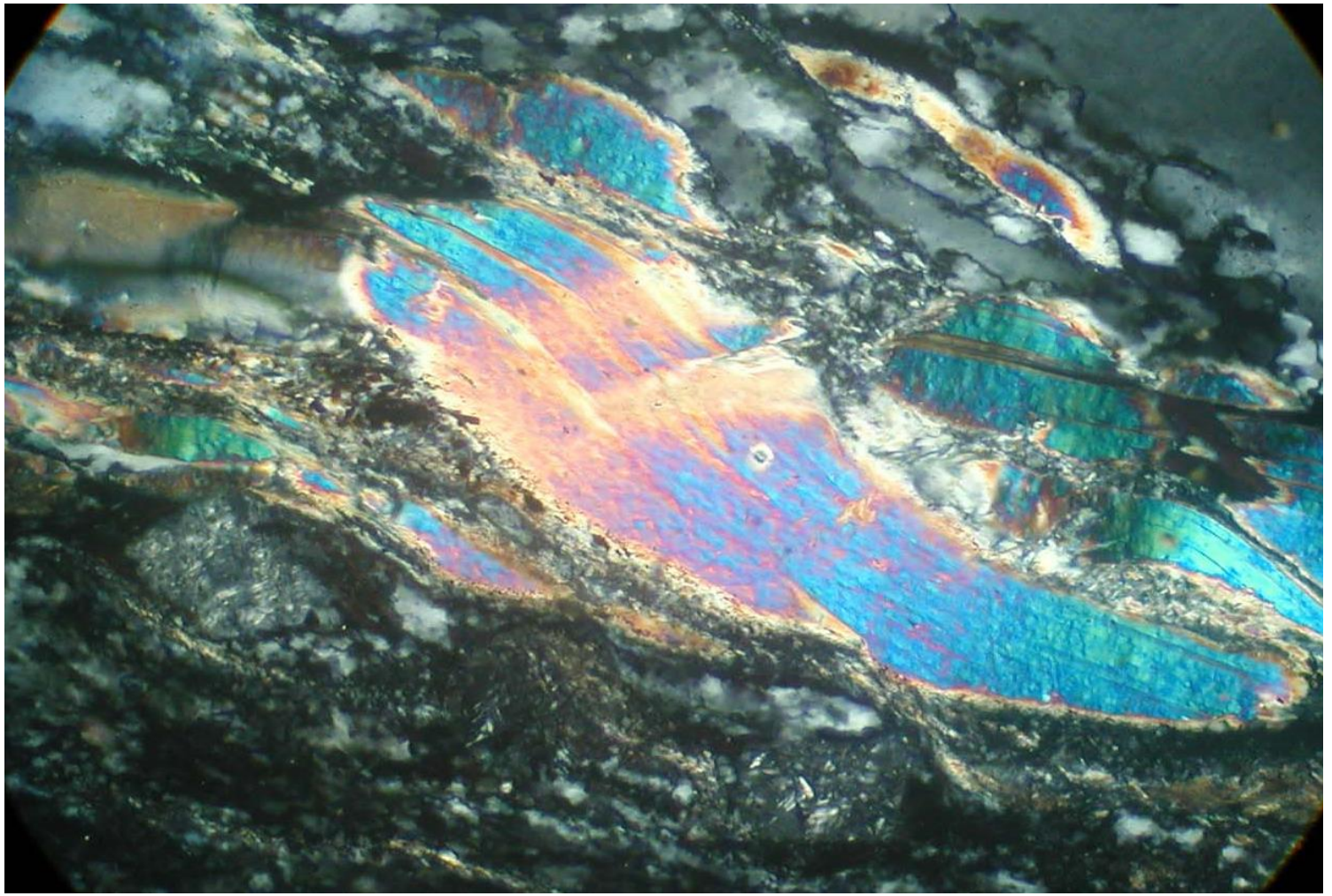
Twins in plagioclase are folded

Deformed biotite: Kinks and bends

PPL

Cleavage is folded; Angular closure

Sharp angle between two limbs; Kink



CPL

Cleavage is bent, gradually changes orientation; Undulose extinction

Crystal defects: the agents of deformation

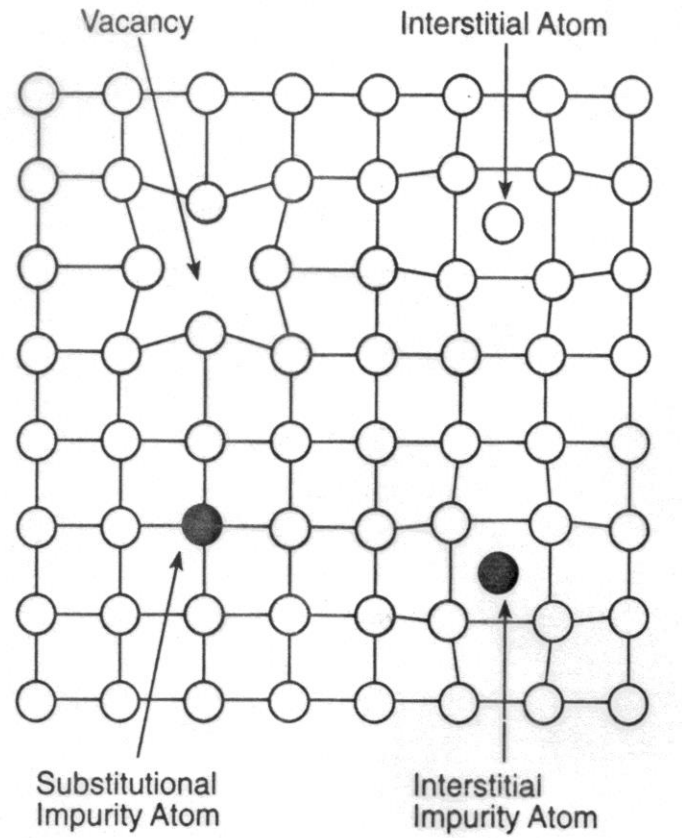


Figure 4.10 Various types of point defects within a crystal.

1. Zero dimensional or point defects: Vacancies, interstitials, etc.
2. One dimensional or line defects: Dislocations
3. Two dimensional or planar defects: Grain boundaries

Grain-boundary dislocations

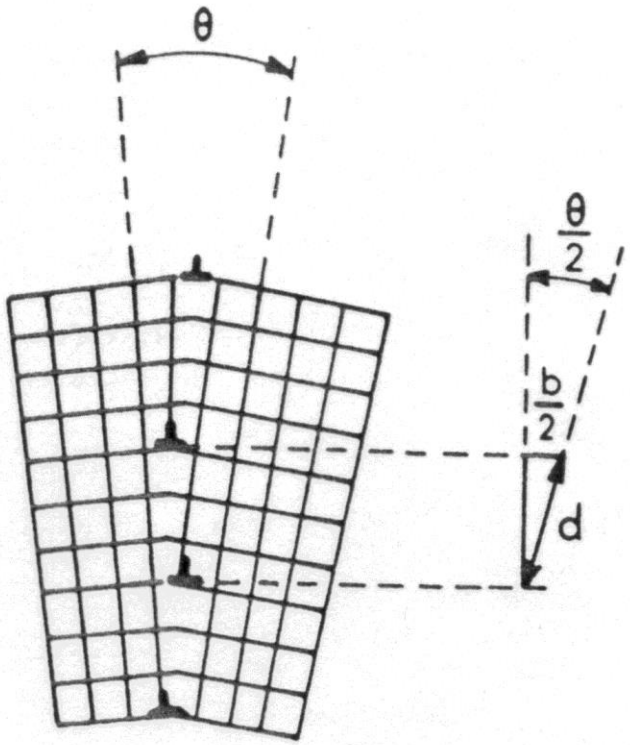


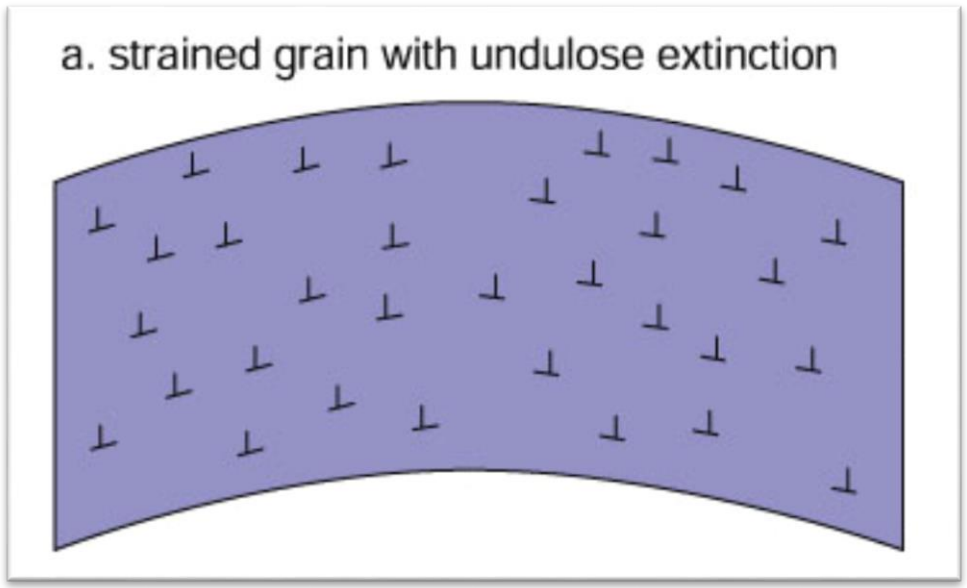
Fig. 3.40. Symmetrical edge dislocations tilt wall separating two subgrains misoriented by an angle θ

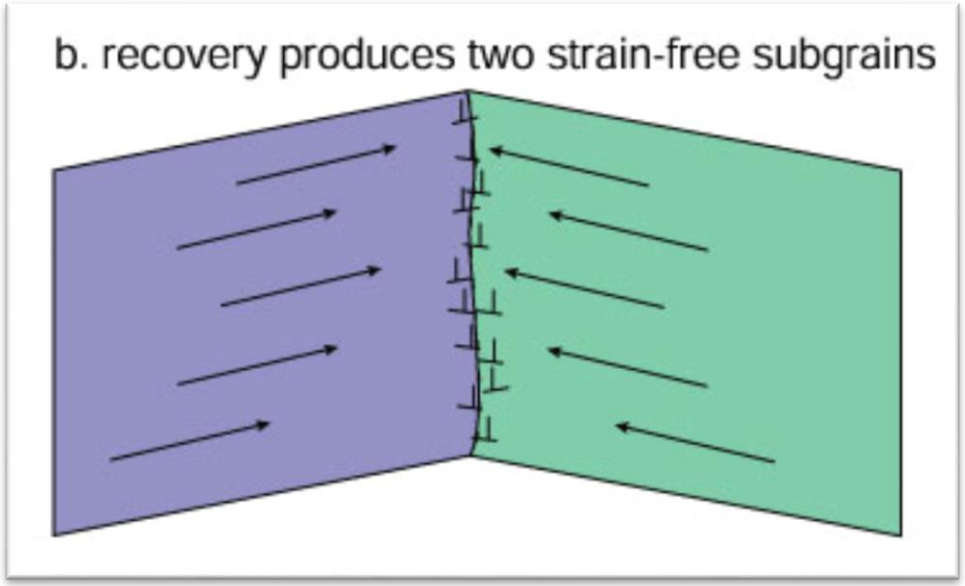
Under stress, dislocations move. Arrangement of the dislocation in a plane leads to orientation difference (misorientation) at the two sides of the plane;

Small misorientation at the boundary (subgrain boundary)

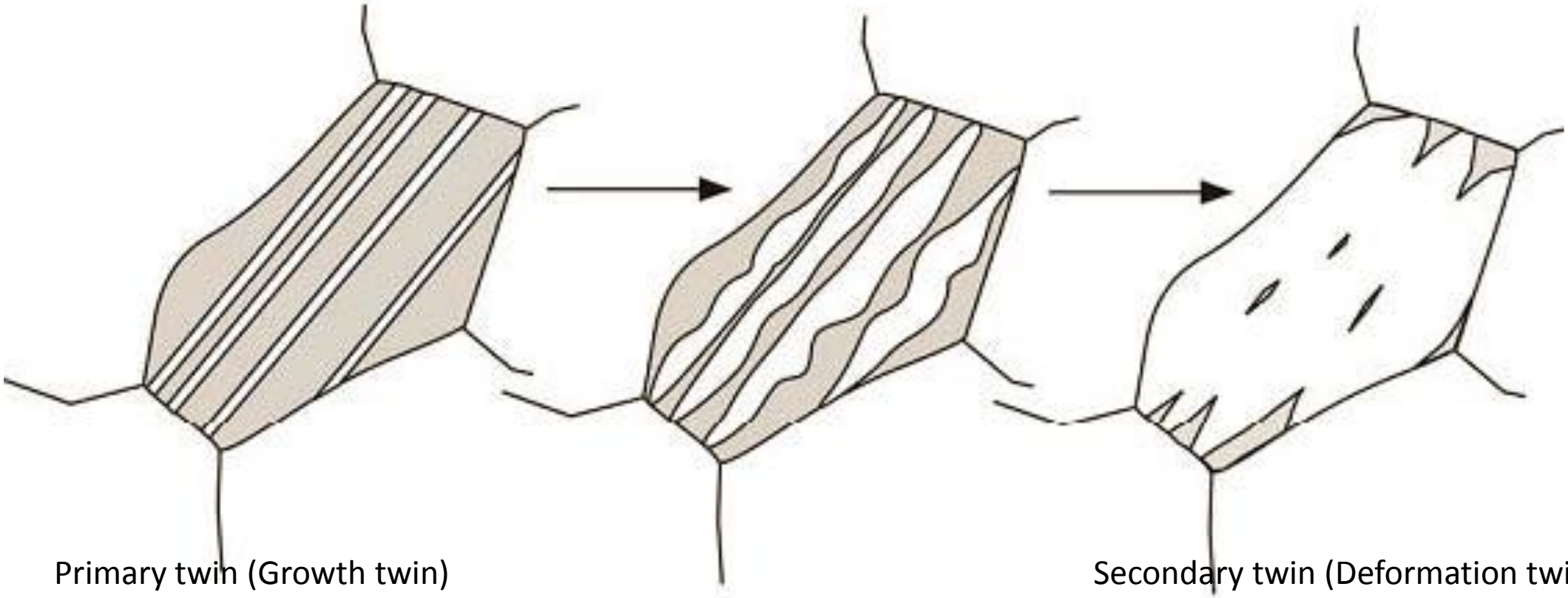
Large misorientation at the boundary (grain boundary)

Evidence of deformation within Crystals





Interfingering pattern



Primary twin (Growth twin)

Secondary twin (Deformation twin)

Twin boundary migration recrystallization in calcite

Growth twins vs. deformation twins

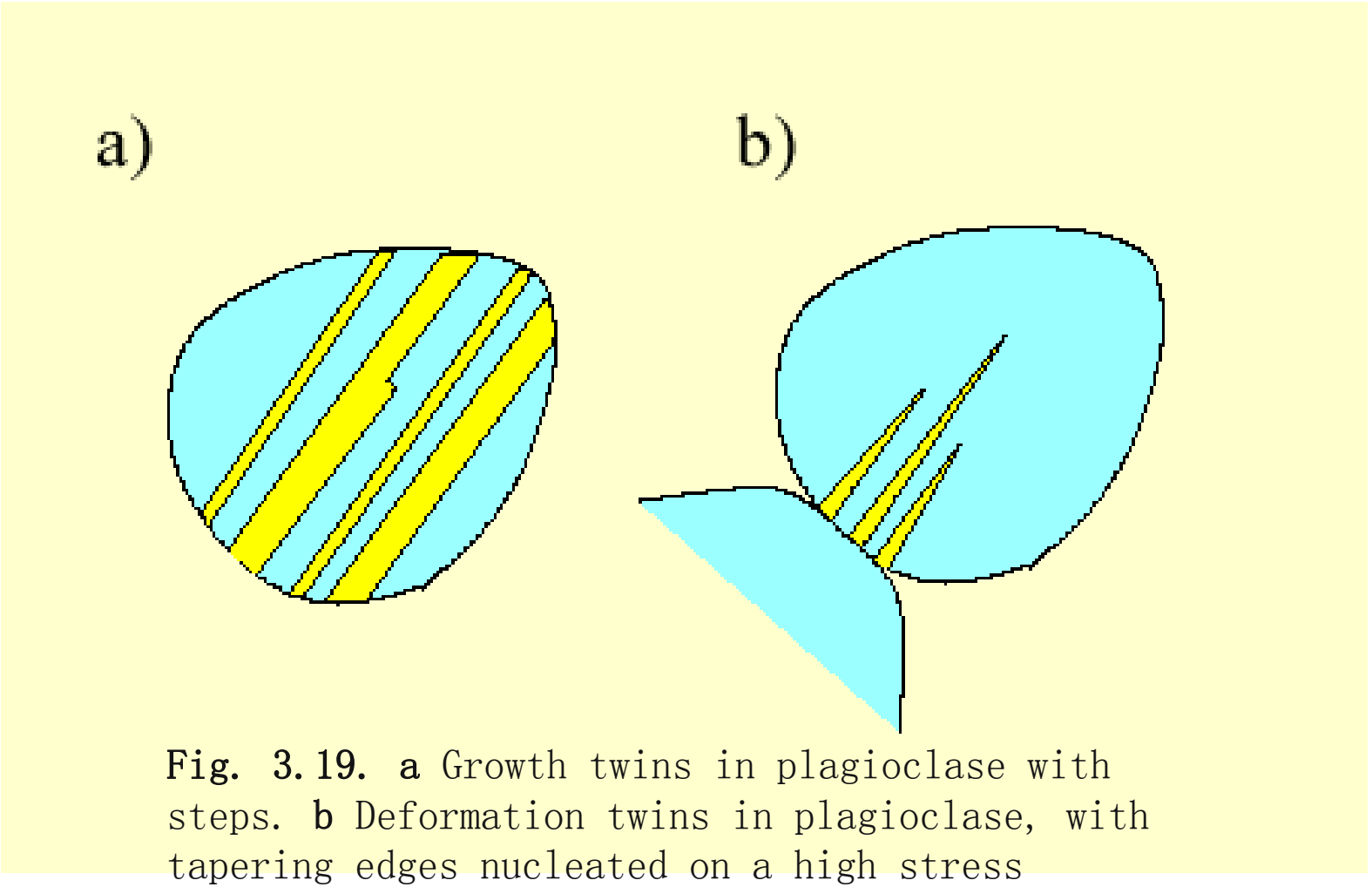
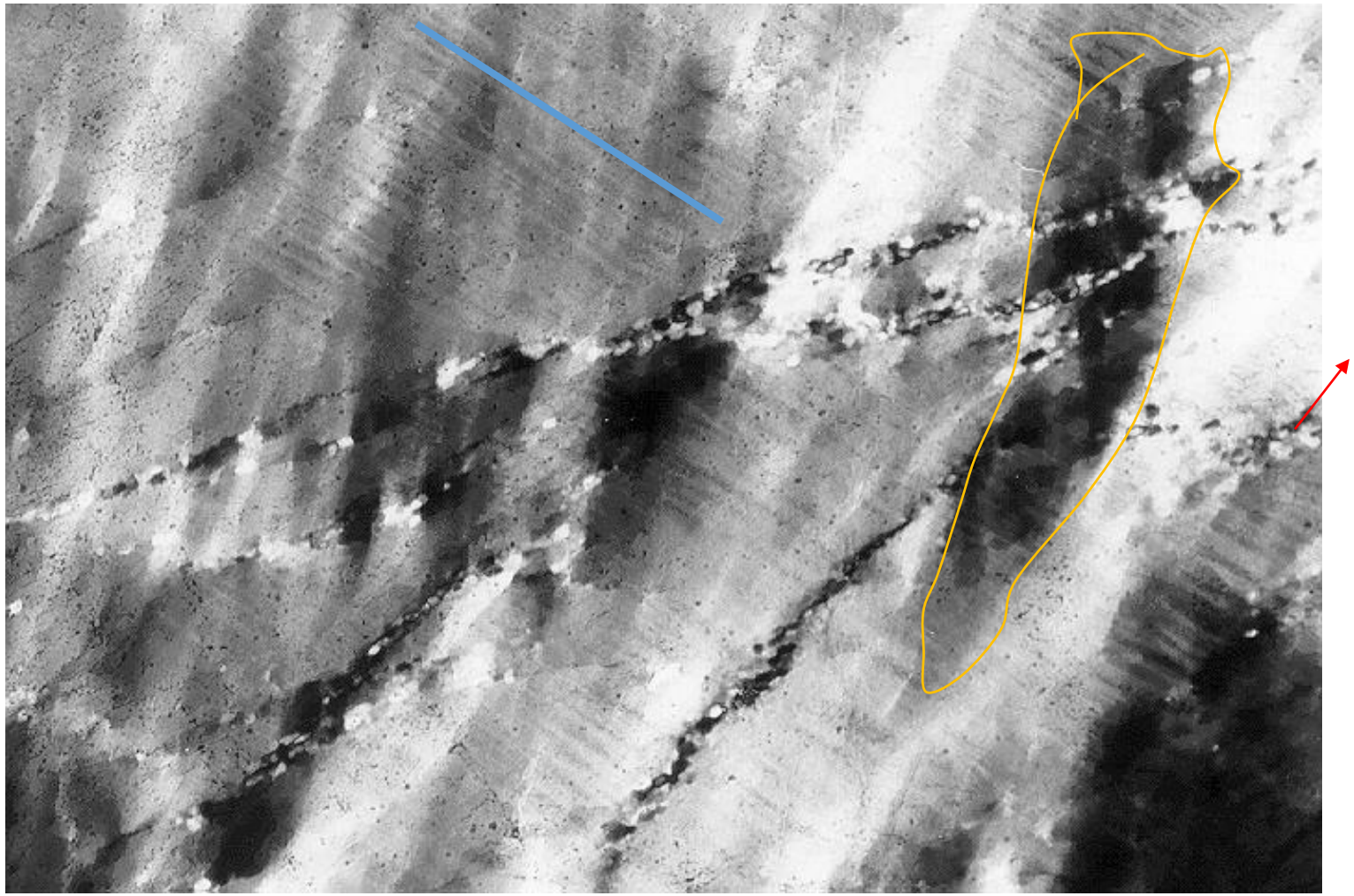


Fig. 3.19. a Growth twins in plagioclase with steps. b Deformation twins in plagioclase, with tapering edges nucleated on a high stress site at the edge of the crystal

Quartz grain with deformation lamellae

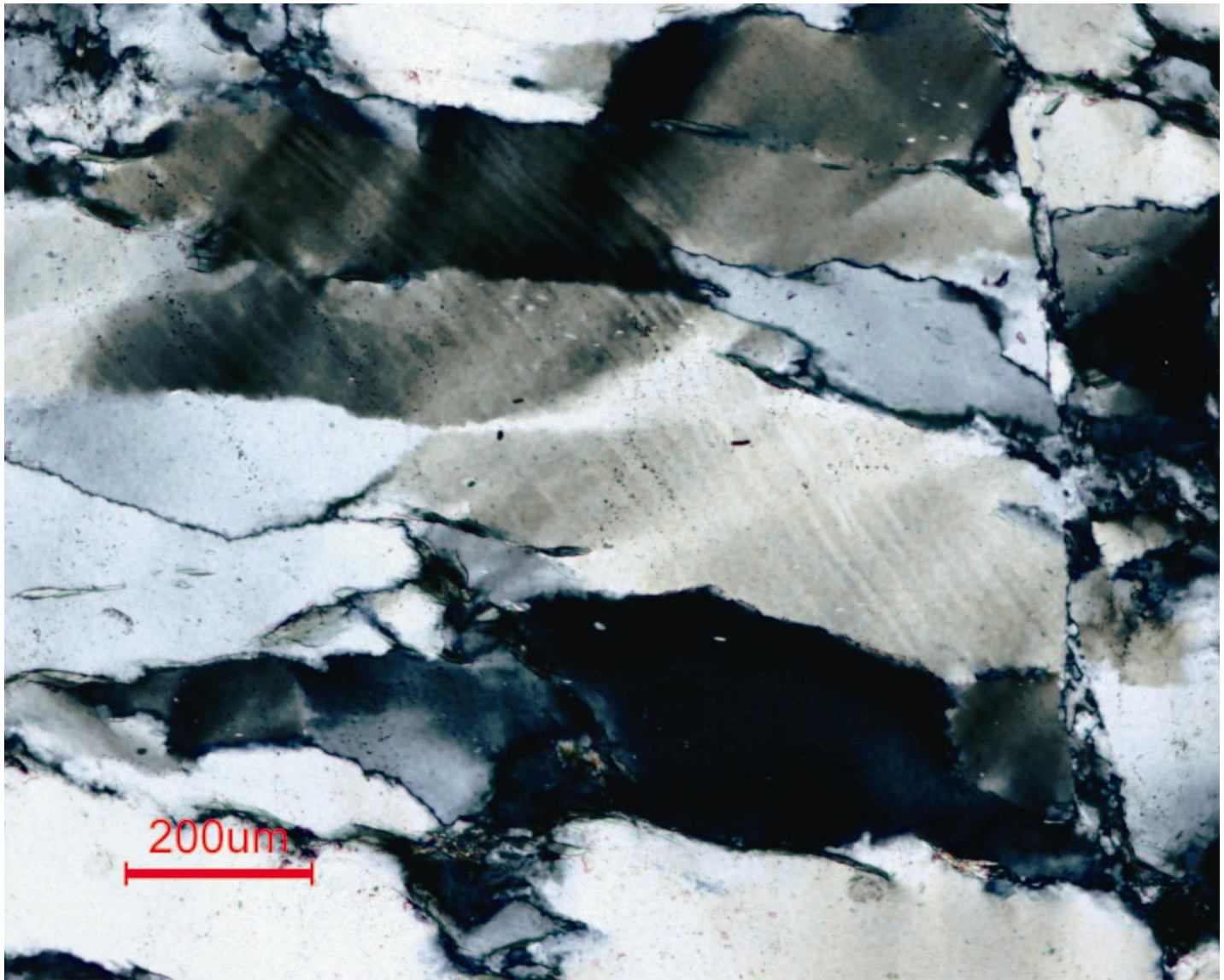


Subgrain

Dynamically recrystallized grain

Deformation lamellae

Quartz grain with deformation lamellae



Porphyroclast VS porphyroblast

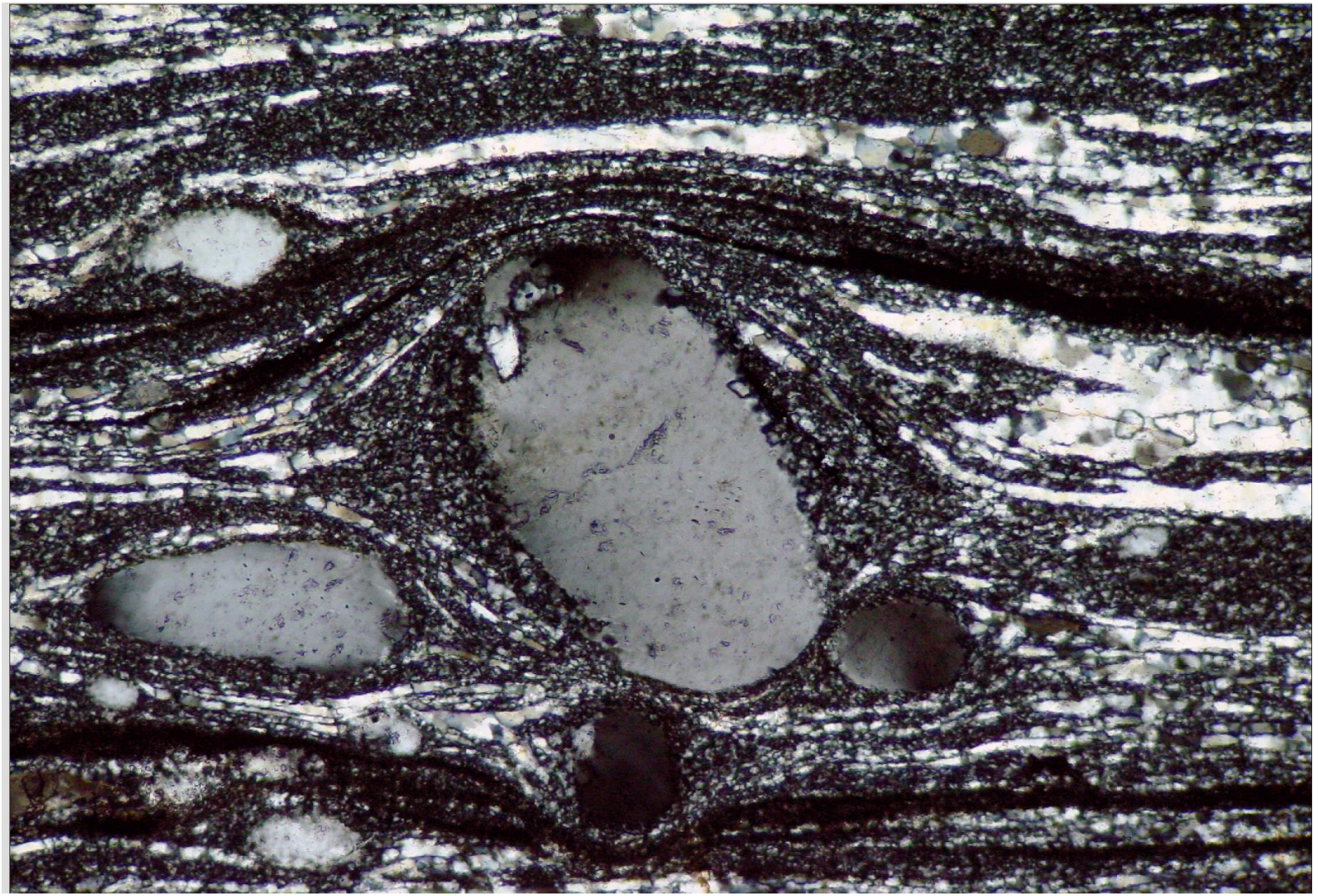
Based on grain size: clasts and matrix

- Porphyroclasts: Grain size decreases during deformation.

  Break apart; dynamic recrystallization

- Porphyroblasts: Grow. Grain size increases.

Porphyroclasts or porphyroblasts?



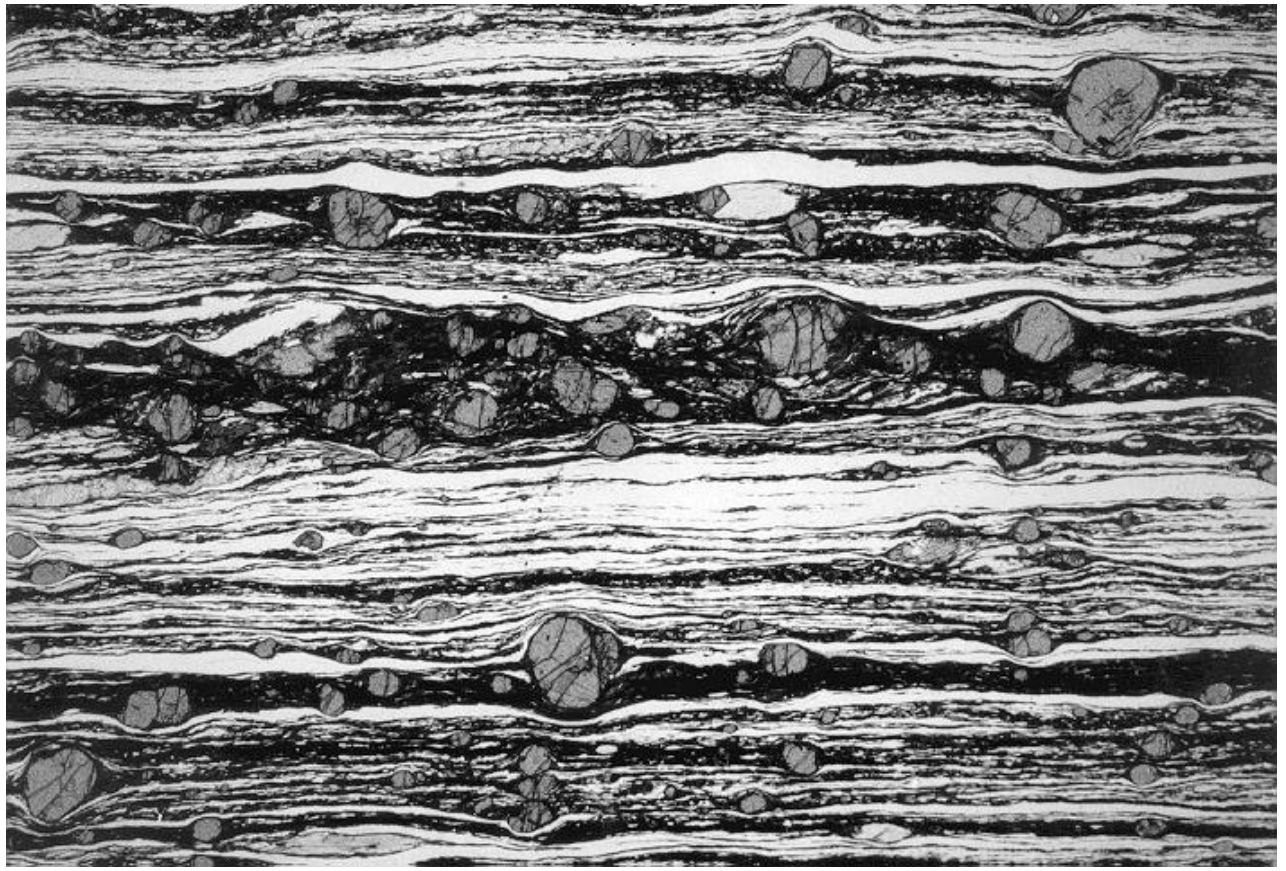
CPP (Cross polarized light)

Clasts: feldspar
Matrix: small quartz grains; some feldspar grains; probably some micas; oxides

Foliation is defined by elongated quartz ribbon (grains), and mica and opaque minerals (oxide) layers

(1) Foliation is deflected around clasts
(2) Strain shadow presents
Clasts existed before deformation.
Undulose extinction and elongated rounded clasts: Stretched; sharp edges removed
Porphyroclasts

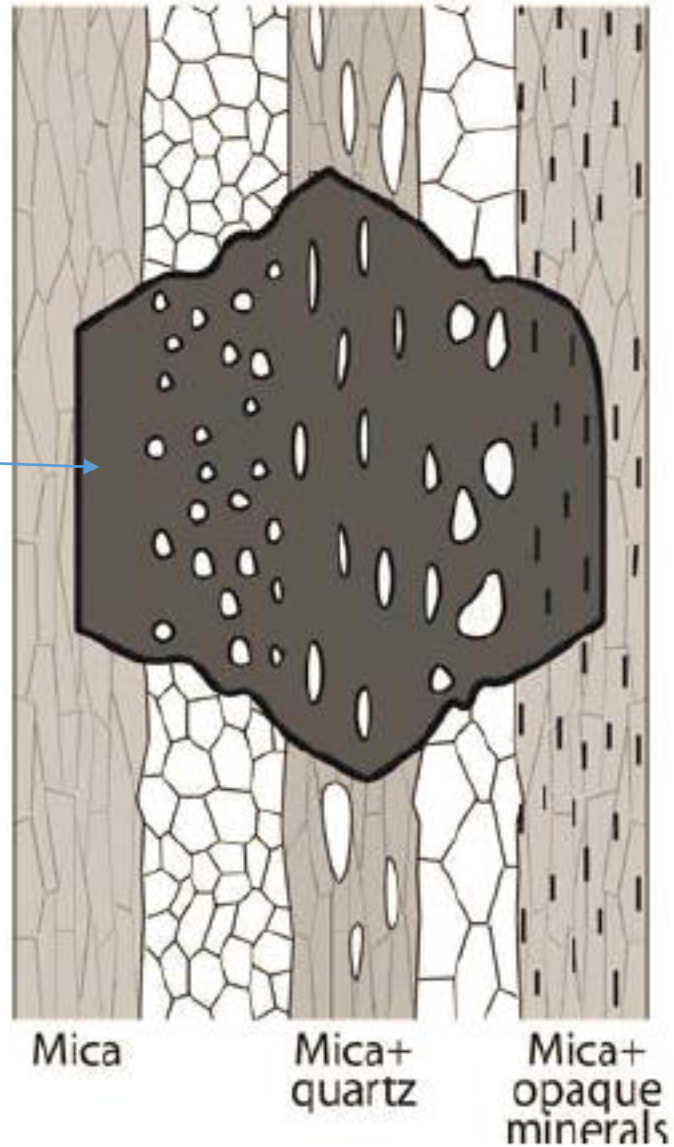
Porphyroclasts or porphyroblasts?



Granite mylonite with a σ-type porphyroclast of K-feldspar in a matrix of recrystallised quartz and other minerals. Section parallel to the stretching lineation and normal to the foliation. Dextral shear sense. St. Barthélemy Massif, Pyrenees, France. PPL

Fractures within clasts

Porphyroclast or porphyroblast?



Inclusion:

Same composition as outside

internal foliation S_i

External foliation S_e:

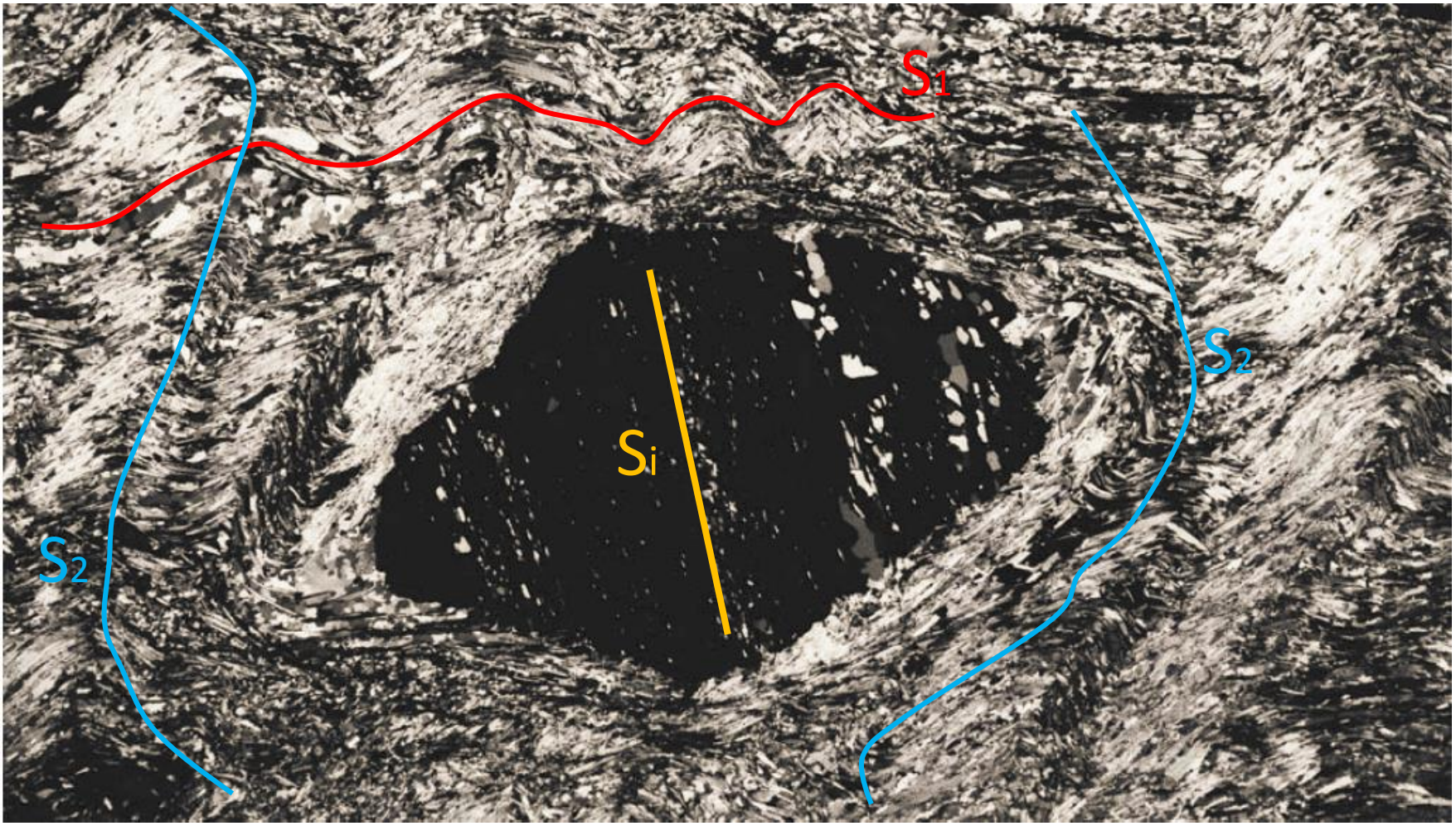
Not deflected around clasts

Truncated by clasts

Clasts overprinted on Se

Si//Se

Clast grew after the foliation was developed

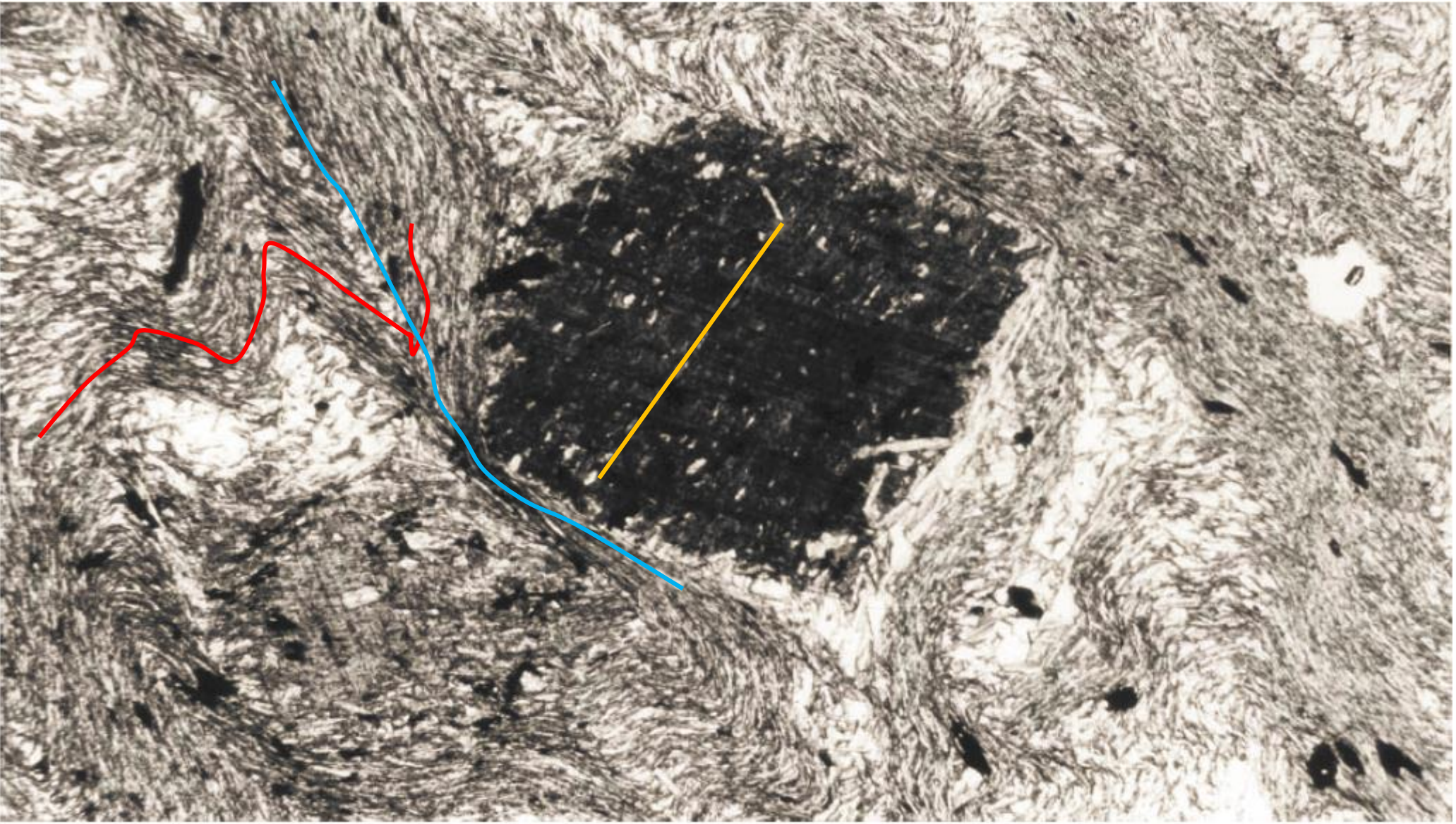


garnet in garnet-mica schist

Width of view 20 mm. CPL

External foliations: S1, S2

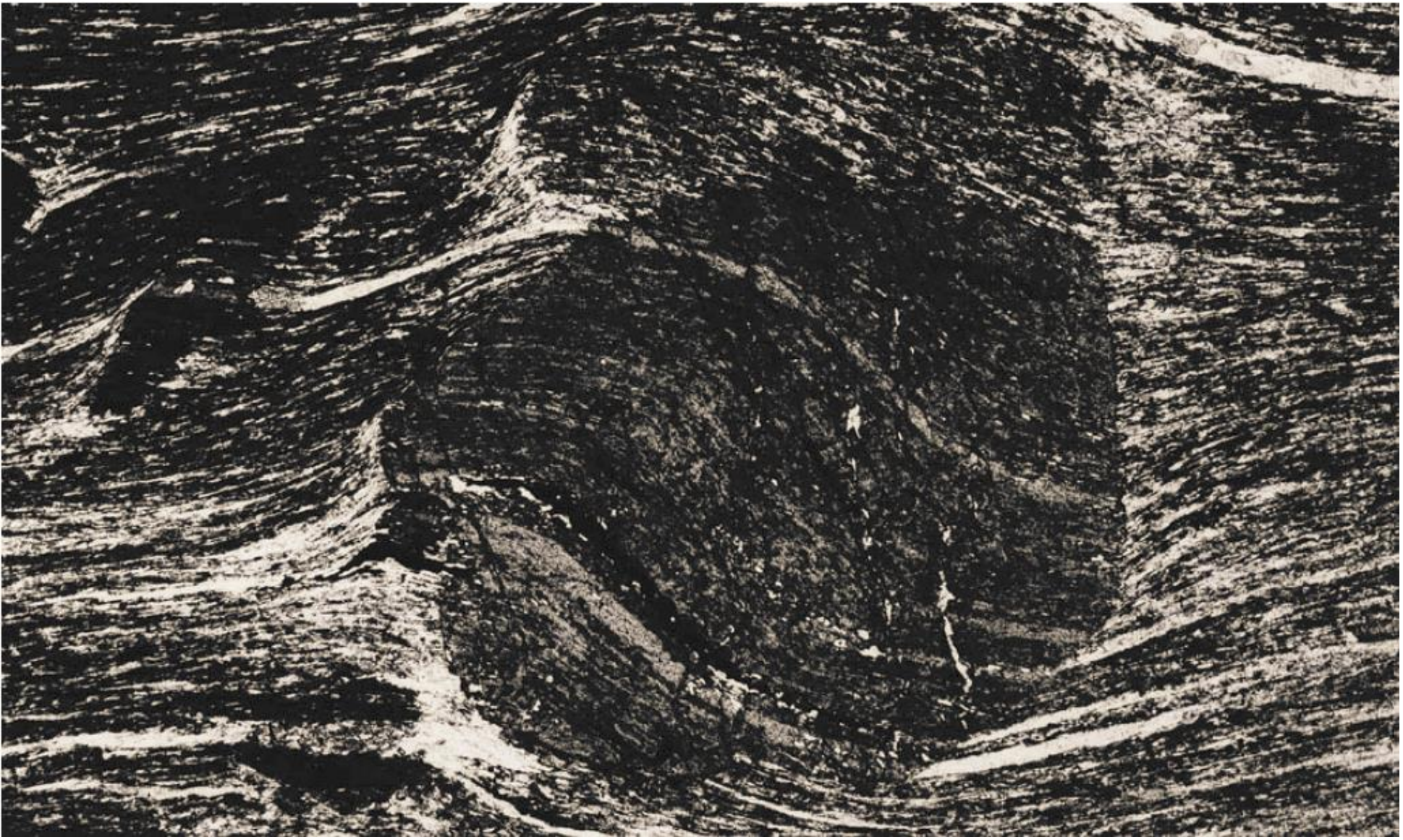
Internal foliations: Straight
one foliation is deflected
around the clast



Biotite clast

Porphyroclast or porphyroblast?

biotite phyllite

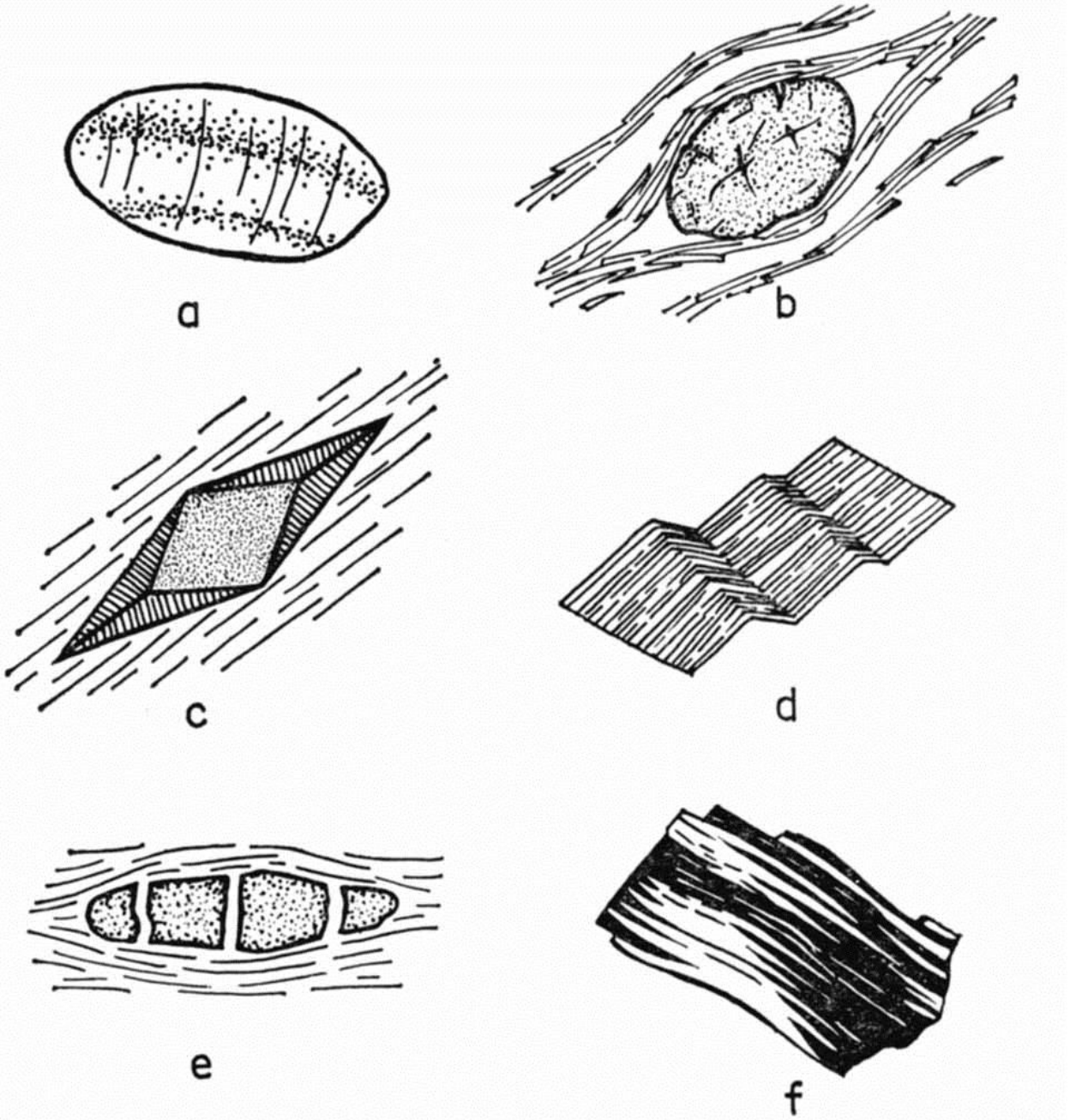


garnet clast

Porphyroclast or porphyroblast?

Before, during or after deformation?

garnet in garnet-kyanite schist Width of view 17 mm. PPL

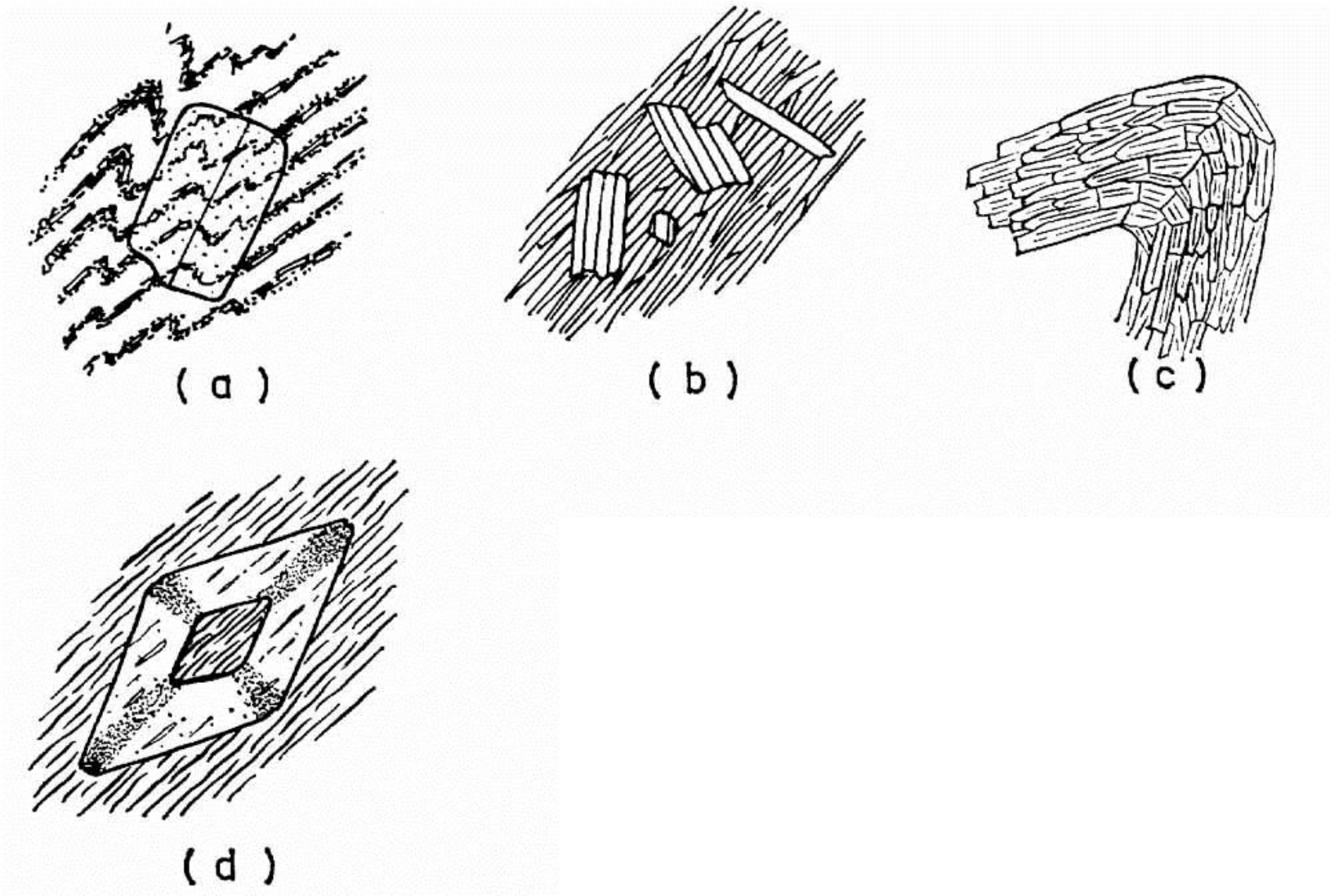


Pre-kinematic crystals

a. Bent crystal with undulose extinction
b. Foliation wrapped around a porphyroclast
c. Pressure shadow or fringe
d. Kink bands or folds
e. Microboudinage
f. Deformation twins

Typical textures of pre-kinematic crystals. From Spry (1969) *Metamorphic Textures*.

Post-kinematic crystals



a. Helicitic folds
b. Randomly oriented crystals
c. Polygonal arcs (crystal NOT bent)
d. Internal foliation is concordant with external foliation

Typical textures of post-kinematic crystals. From Spry (1969)

Syn-kinematic crystals

Spiral Porphyroblast

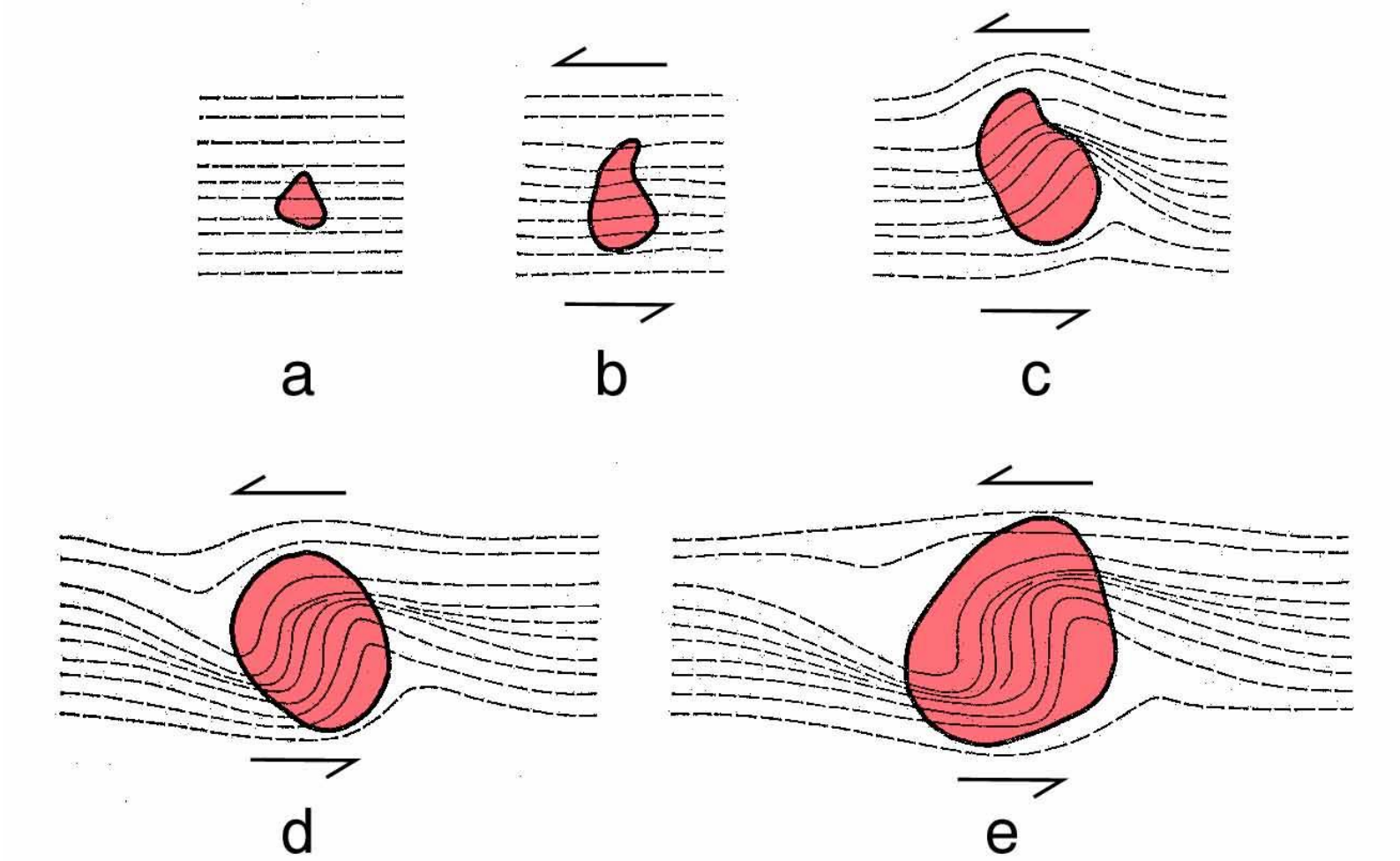
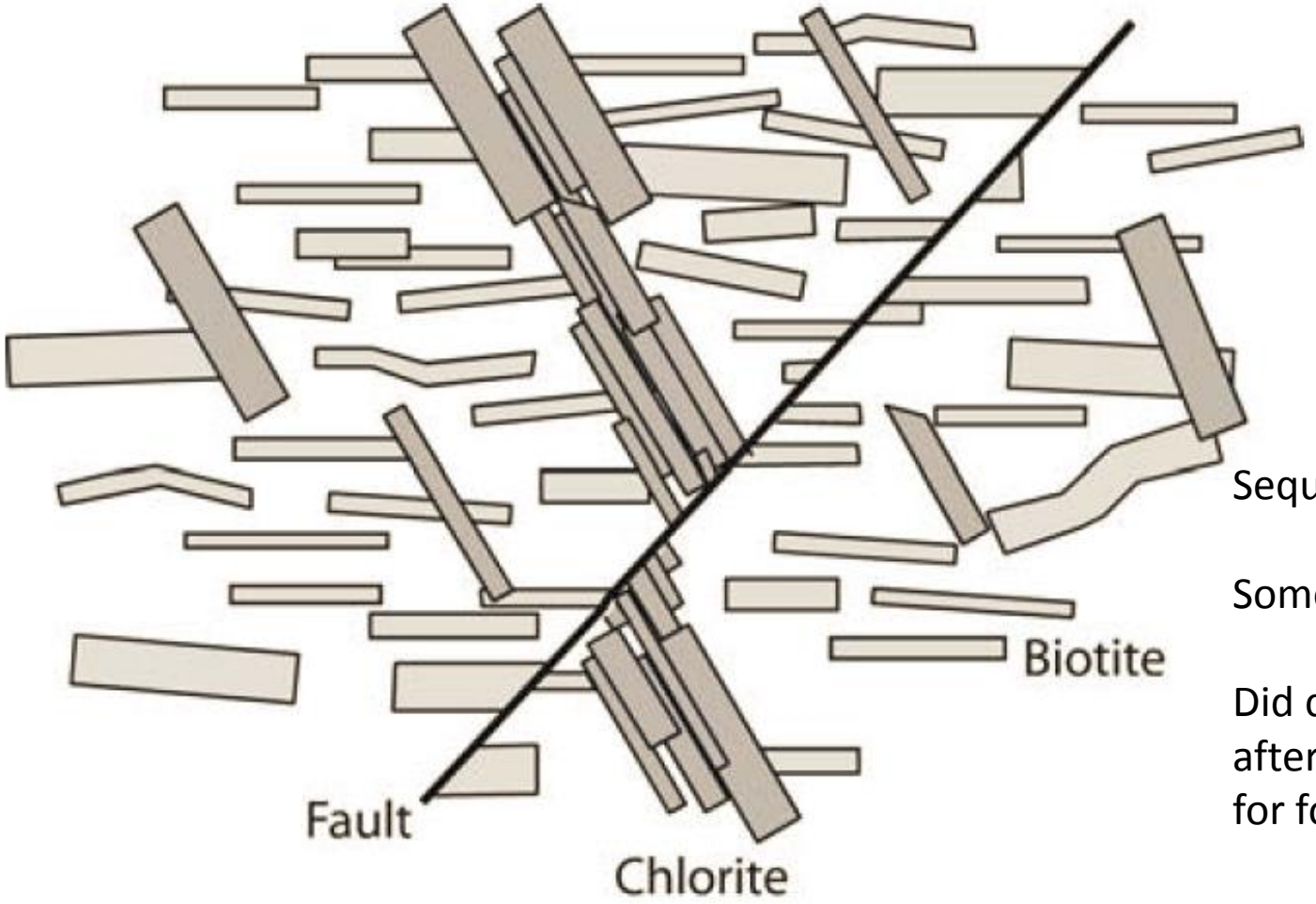


Figure 23.38. Traditional interpretation of spiral S_i train in which a porphyroblast is rotated by shear as it grows. From Spry (1969) *Metamorphic Textures*. Pergamon. Oxford.

Overprinting



Sequence of overprinting relationship?

Some biotite crystals are folded.

Did chlorite crystal grow before, during or after the deformation that is responsible for folding of biotite?